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## Germination and Mortality on the South Slope Site, Rodent-Proof Enclosure

The following notes are a summary of results from the preliminary compilation and analysis of data for the 36 milacre plots in the rodent-proof south enclosure. Only totals for the season were analyzed. Mortality percentages were based upon total number of seedlings germinated.

Germination. The average germination per plot for this series was 25.5 percent, based upon an approximate 1,000 seeds planted per plot. Germination was 3.4 percent higher on litter-covered than on bare mineral soil plots, but this difference is of no statistical significance. The range of percentages was from 6.0 to 47.9.

Mortality. The average total mortality (excluding thinned and broken seedlings) was 39.9 percent, with a standard deviation of ± 14.2 percent or a standard error of the mean of ±2.4 percent. The range of percentages was from 9.4 to 82.2. Losses were significantly greater on litter than on bare surfaces and greater on unshaded than on shaded plots. Although losses on heavily watered plots were about 5 percent less than on lightly or unwatered plots, the differences were inconsistent and of no real significance. Interactions also proved to be of no significance. There was no apparent concentration of high or low losses in any particular portion of the enclosure, as well as could be judged from the charting of heat and damping-off percentages on a plat of the area. The average percentages and range of percentages of mortality from the various causes were as follows:

| | Average | Range |
|---|---|---|
| Birds | 5.8% | 0.8 - 13.3% |
| Insects | 1.2 | 0.0 - 5.7 |
| Fungi | 8.2 | 0.0 - 27.4 |
| Heat | 21.0 | 2.0 - 63.1 |
| Drought | 1.3 | 0.0 - 17.2 |
| Unknown | 2.4 | 0.2 - 5.4 |
| Total | 39.9 | 9.4 - 82.2 |

Destruction of seedlings by birds was fairly uniform for all conditions of surface, shade, and moisture. No significant relations were indicated by the analysis of variance. Losses on shaded plots were slightly less than on unshaded plots, suggesting that the shade frames may have afforded a little protection.

Losses ascribed to insects were nearly twice as heavy on bare as on litter surfaces and slightly greater on shaded than on open plots, but individual variations were so great that these differences may have been accidental rather than real. No trend in relation to artificial watering was evident.

Mortality caused by fungi (largely damping-off) was on the average 4.1 percent greater on litter than on bare surfaces, and 2.6 percent greater on shaded than on unshaded plots. The first difference was indicated by analysis of variance to be of high significance; the latter, of doubtful significance (ratio below that for .05). The relations of these losses to surface was different under the two conditions of shade--in the open, losses were higher on bare surfaces; under shade, they were much higher on litter surfaces. Shading resulted in lower losses on bare surfaces, higher losses on litter surfaces. Mortality was thus least on bare shaded plots, greatest on the litter shaded plots. This interaction is indicated by the analysis to be of high significance. It is well known that damping-off organisms grow aggressively only under particular combinations of heat and moisture, and this experiment may reveal just what natural conditions provide this optimum combination in this region.

Losses caused by fungi appeared to decrease with increase of watering, this effect being more pronounced on litter than on bare surfaces and on shaded than on unshaded plots. The water relation by itself and its interaction with surface are not of statistical significance, but the water-shade interaction is of moderate significance. The deterrent effect of increased watering is greatest where losses are highest--on shaded litter surfaces.

Heat was the most important single agency of mortality, having been charged with 53 percent of the total deaths. Heat kill on unshaded plots was more than double that on shaded plots and on litter surfaces more than double that on mineral surfaces. Both of these differences were shown to be of high significance. The interaction of surface and shade approaches the point of low significance, apparently reflecting the fact that difference between loss in the open and under shade was much larger on litter than on bare surfaces. Likewise the excess of losses on litter over those on bare surfaces was much greater in the absence of shade. Apparently the shade frames were not entirely effective in preventing heat kill, although a large proportion of the 12.4 percent loss indicated for shaded plots occurred either before the frames were placed or around the unprotected edges of the beds.

Watering apparently had little or no effect upon losses caused by direct insolation. The averages for unwatered, lightly watered, and heavily watered plots are all within 1 percent of the general average. There is a suggestion of an interaction with surface (but of no statistical significance), in that increased watering appears to be accompanied by higher losses on bare surfaces and lower losses on litter surfaces, especially in the open. The latter would seem the more logical trend, if any, but here the two counterbalance each other in the general average.

The relationships of drought losses to treatment are poorly defined because they were generally so low (0 on 24 plots) and seemed to be concentrated on a few plots or spots largely regardless of controlled conditions. There is also considerable question as to the proper field identification of drought kill. Hence no general conclusions should be drawn from the averages listed. The losses on litter surfaces appear to be significantly higher than on bare surfaces, but there is no ready explanation of such a relationship. The relation to watering was of little or no significance, although it may be noted that losses were negligible on heavily watered plots (only 2 seedlings on one plot). Practically all of the drought losses occurred about May 28, before roots had penetrated deeply and while the soil in most spots was fairly moist and did not appear to be in need of watering. Undoubtedly in a dryer year drought kill would be much greater and should show strong relationships to all factors, especially to watering treatments.

The analysis of mortality from unknown causes shows a lack of significant relationship to any of the controlled factors, as might be expected. Such a finding indicates that these so-called "unknown" losses do not belong under any single classified cause nor are they ascribable to any single outstanding unrecognized agency. Rather they are probably distributed fairly uniformly through all classes of cause, both those listed and those unmeasured factors of inherent poor vigor, variable soil character, root disease, invisible mechanical injury, etc.

The mode of analysis, which largely follows that of Haig (Yale Bul. No. 41), seems to serve the purpose reasonably well and needs only the incorporation of the factor of site to be applicable to the fall analysis of all-season, all-age germination and mortality. Considering that destruction by rodents was so extremely heavy on unprotected portions that few to no seedlings were left for other agencies, it seems best to make a separate analysis for non-rodent-proof plots. Possibly the analysis of variance of losses by other causes may be omitted or much reduced, except where data may be sufficient to strongly substantiate or show material differences from the relations shown for rodent-proof plots.

The use of total germination as basis of mortality percentages seems to be satisfactory for rodent-proofed plots. The subtraction of "broken" losses to provide a base free from this arbitrary element was considered, but the idea was abandoned when it was noted that most natural losses had occurred previous to dates of thinnings, and thus the full number of seedlings "available for destruction" was a more logical base. The procedure of subtracting losses caused by rodents or birds, which occurred mostly at the very beginning of the season, to provide a base for further mortality percentages would not be unreasonable and may be followed in the analysis of non-rodent-proof plots. Space was also allowed for such computation on the

rodent-proof plots in case it is later desired for comparison. However, when it was found in the compilation of south enclosure data that destruction by birds in the rodent-proof area was a relatively small proportion of the total and that such losses were fairly uniform among all plots, there seemed to be no advantage in the initial rejection of these losses and the computation of a double set of percentages. The desirability of subtracting all biotic losses (rodents, birds, insects, and fungi) before computing relative losses caused by physical factors, as was done by Haig, was also considered, but did not seem logical here because of the chronological order of losses through the season.

The compilation and presentation in simple and understandable form of the great mass of data showing losses of seedlings of various age classes ("colors") by ten-day periods through the season, according to cause and plot treatment and in relation to measured physical factors, is a complicated problem the detailed solution of which has not yet been worked out. The gross, all-season analysis should first be worked out for all sites and enclosures. Then the more detailed compilation and analysis can be planned to give emphasis to those factors and causes which are most significant. The data by periods will thus help to explain the differences noted and complete the picture of various factor influences. It is very doubtful whether analysis of variance or other tests of significance can be applied to the broken-down data in any systematic manner, both because of the magnitude of the job and because of the small numbers involved and their irregular distribution resulting in a great many gaps in the data. In a few specific cases where data are sufficient and it is desirable to test or demonstrate significance this may be done. The possibility of important trends in the periodic data which were indicated as non-significant in the all-season analysis should of course not be overlooked, but such should be apparent from a general inspection of tabulations and averages.

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# GERMINATION

## Summary and Analysis of Variance

## South - R.P.

On a single half-enclosure the only controlled factor which might conceivably have influenced total germination is Surface (Bare vs. Litter), at least on the South where germination was almost complete before shade frames were placed and artificial watering begun. On the North and possibly on the Flat analysis might be made to see if any material influence of shade and water. Analysis will also be made of data for all enclosures to determine amount and significance of differences associated with Site and Rodent Protection.

Average Germination Percentages (Based on 1000 seeds per plot)

| | | M | S.D. | S.E.M |
|---|---|---|---|---|
| Surface: | Bare - | 23.79% | 9.98 ~~9.98~~ | ~~2.14~~ 2.35 |
| | Litter - | 27.23 | " | " |
| | All - | 25.51 | " | ~~1.51~~ 1.66 |

Analysis of Variance

| Source of Variation | Deg. Freedom | Sum of Squares | Mean Square | Ratio | Signif. Ratios for .05 | .01 |
|---|---|---|---|---|---|---|
| Total | 35 | ~~2897.93~~ 3493.29 | ~~82.86~~ 99.81 | | | |
| Bet. Surfaces | 1 | 106.44 | 106.44 | ~~1.30~~ 1.07 | 4.12 | 7.42 |
| Within Surfaces | 34 | ~~2791.49~~ 3386.85 | ~~82.10~~ 99.61 | | | |

~~9.98~~

Conclusion: Altho germination averaged 3.44% higher on litter than on bare surfaces, this analysis shows that this difference is of no real significance, because of the wide variation in germination on individual plots. The latter varied from 6.0% to 47.9% on this site. A comparison of difference with its standard error (about ~~3.03~~ 3.35) indicates a chance that in 1 out of about 7 similar series of plots the germination on bare surfaces would exceed that on litter surfaces.

Computations: $C.T. = \frac{\overline{\Sigma\%}^2}{36} = \frac{843274.89}{36} = 23424.30$

Tot. Sum Sq. $= \sum_1^{36} (\%)^2 - C.T. = 26917.59 - 23424.30 = 3493.29$ ~~2897.93~~

Sum Sq. Bet. Surf. $= \frac{(\Sigma\%_B)^2 + (\Sigma\%_L)^2}{18} - C.T = \frac{423553.25}{18} - 23424.30 = 106.44$